

CPAP HUMIDIFIER

1 CROSS-REFERENCE TO RELATED APPLICATION

2 This application claims the benefit of U.S.

3 Provisional Patent Application Serial No. 60/225,171

4 filed on August 14, 2000.^{pro tem file}

5 BACKGROUND OF THE INVENTION

6 Field of the Invention

7 The present invention relates generally to a passive
8 humidification apparatus, and more specifically to a
9 humidifier for a continuous positive airway pressure
10 (CPAP) device.

11 Relevant Prior Art

12 CPAP devices are now commonly used to treat a
13 variety of respiratory disorders, including sleep apnea.
14 CPAP devices normally consist of an air pump connected to
15 a mask worn by a patient while they are sleeping.

16 Although CPAP devices have been very successful in
17 treating these disorders, there is at least one
18 associated drawback. The air that is introduced into the
19 patient's respiratory system tends to have the effect of
20 drying out mucous membranes. In order to mitigate this
21 problem, several types of passive humidifiers have been

1 One such passive humidifier is disclosed in U.S.
2 Patent No. 5,231,979 to Rose et al. This humidifier
3 consists mainly of a chamber having an inlet and an
4 outlet and that is partially filled with water. In
5 operation, the outlet of a CPAP device is connected to
6 the inlet of the humidifier and the mask is connected to
7 the outlet of the humidifier. When the air supplied by
8 the CPAP device enters the humidifier chamber and passes
9 over and contacts the water, some moisture is added to
10 the air through evaporation before the air ultimately
11 passes to the mask and into the patient. This
12 humidifier, however, is very ineffective and normally
13 produces insufficient levels of humidity.

14 To improve the efficacy of the passive
15 humidification system, some such humidifiers have been
16 provided with baffles located within the humidifier
17 chamber. One such baffled humidifier is disclosed in
18 U.S. Patent No. 5,598,837 to Sirianne, Jr. et al. In
19 this humidifier, air is made to flow around the baffles
20 which increases its length of contact with the water and
21 also tends to augment the evaporation process. However,
22 this humidifier design still falls short of providing an
23 optimum level of moisture in the output air.
24 Additionally, the shape of this humidifier precludes most

1 system.

2 BRIEF SUMMARY OF THE INVENTION

3 According to one aspect of the present invention, a
4 humidifier for a continuous positive airway pressure
5 device is provided. The humidifier comprises a
6 humidifier body, an air inlet provided to the humidifier
7 body, an air outlet provided to the humidifier body, and
8 a plurality of chambers defined within the humidifier
9 body. The humidifier further comprises a plurality of
10 baffles between one of the plurality of chambers and an
11 adjacent one of the plurality of chambers, an opening
12 provided between two of the plurality of baffles, the
13 opening connecting the adjacent two of said plurality of
14 chambers, and a deflector baffle being one of the
15 plurality of baffles, the deflector baffle being located
16 proximate to the opening and defining a serpentine fluid
17 flow path between the adjacent chambers.

18 According to another aspect of the present
19 invention, a humidifier comprises a non-planar dividing
20 wall separating an adjacent two of said plurality of
21 chambers, and an opening in the dividing wall providing
22 fluid communication between chambers.

23 According to a further aspect of the present

1 cover to the base, a chamber defined by the base and
2 cover, an inlet in communication with the chamber, and an
3 outlet in communication with the chamber.

4 BRIEF DESCRIPTION OF THE DRAWINGS

5 FIG. 1 is perspective view of a CPAP humidifier
6 according to an embodiment the present invention;

7 FIG. 2 is plan view of the CPAP humidifier of FIG.
8 1;

9 FIG. 3 is a plan view of a cover portion of the CPAP
10 humidifier of FIG. 1;

11 FIG. 4 is a perspective view of the cover portion of
12 FIG. 3;

13 FIG. 5 is a detail of air flow within a CPAP
14 humidifier according to an embodiment of present
15 invention;

16 FIG. 6 is a sectional view taken along section line
17 6-6 of the CPAP humidifier shown in FIG. 2;

18 FIG. 7 is a sectional detail showing a seam of the
19 CPAP humidifier of FIG. 6;

20 FIG. 8 is a perspective view of a CPAP humidifier
21 according to another embodiment of the present invention;
22 and

23 FIG. 9 is a sectional detail taken along section

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DETAILED DESCRIPTION

2 In a passive humidification system, factors
3 contributing to humidification include increased surface
4 contact and decreased air pressure. By controlling these
5 factors through humidifier design, the overall
6 performance of the humidifier can be increased.

7 One way to positively affect both of these factors
8 is by preventing laminar air flow through the system.
9 When turbulence is introduced, the air does not travel in
10 a straight line, and thus it will remain in the system
11 longer and have increased surface contact with the water.
12 Furthermore, assuming a constant input and output
13 pressure, turbulent flow has the effect of increasing
14 airflow velocity within the system. When the velocity of
15 the air flowing across the surface of the water is
16 increased, the air pressure above the water
17 correspondingly decreases which effectively increases the
18 rate of evaporation. Turbulent airflow can be created in
19 several ways.

20 One way to create turbulence in a system is by
21 designing the system with a high Reynolds number. As
22 will be appreciated by one skilled in the art, the higher
23 the Reynolds number, the greater the incidence of
24 turbulent flow. The Reynolds number of a system is

1 inlet, thereby increasing the velocity of the air
2 traveling through it.

3 Another way to increase turbulence and air velocity
4 is by providing baffles that redirect the airflow.
5 Further, by constricting the airflow space, the baffles
6 will tend to increase the Reynolds number of the system.

7 As will be shown below, the shape and placement of
8 baffles in the system are critical to providing the
9 desired effect.

10 FIGS. 1 and 2 show the exterior of a CPAP humidifier
11 10 according to the present invention. The humidifier 10
12 is provided with an air inlet 12, an air outlet 14, and a
13 humidifier chamber 16. In use, the inlet 12 is connected
14 to the outlet of a CPAP device (not shown) and the outlet
15 14 is connected to a patient delivery device, such as a
16 mask (not shown). Both of these connections are normally
17 accomplished using flexible hose. As best seen in FIG.
18 1, the humidifier 10 comprises a cover portion 18 and a
19 base portion 20.

20 FIGS. 3-5 show the cover 18 of the humidifier 10
21 removed from the base 20. The cover 18 is provided with
22 a plurality of arced baffles 22. Alternatively, the
23 baffles 22 could be curvilinear, flat or formed from a
24 plurality of flat portions connected at an angle.

1 effectively divided into four separate parallel chambers
2 24, 26, 28, 30. The term non-planar as used herein with
3 reference to the dividing wall refers to a body that is
4 made up of at least two separate components which are not
5 coplanar with respect to one another. For example, the
6 wall of the present embodiment comprises individual
7 baffles 22 which are curved and/or angled with respect to
8 one another.

9 The first chamber 24 is adjacent to the air inlet 12
10 and the second chamber 26. The second chamber 26 is also
11 adjacent to the third chamber 28. The third chamber 28
12 is also adjacent to the fourth chamber 30. The forth
13 chamber is also adjacent to the air outlet 14.

14 Openings 32 are provided between adjacent baffles 22
15 to allow adjacent chambers 24-30 to communicate with one
16 another. Further, the baffles 22 do not extend
17 completely to the base 20, leaving a space connecting all
18 of the chambers 24-30. Each of the openings 32,
19 excluding one opening 34 that is in closest proximity to
20 the air outlet 14, is provided with a deflector baffle 36
21 spaced away from the opening 32. The deflector baffle 36
22 is provided as part of the dividing wall and defines a
23 serpentine flow path between two adjacent chambers. The
24 term serpentine, as used herein, refers to a path which

1 opening 34.

2 As an alternative, a dividing wall could be provided
3 that is single curvilinear baffle being provided with
4 apertures to serve as openings 32. Thus, a non-planar
5 dividing wall according to the present invention need not
6 comprise separate baffles wherein the space between them
7 provides the openings 32.

8 Additionally, an inlet baffle 38 is provided within
9 the air inlet 12 to direct airflow toward the far end 40
10 of the first chamber 24. This helps better distribute
11 the air flow among all of the openings 32, since the air
12 flow will naturally favor the openings 32 closest to the
13 inlet 12.

14 In operation, the humidifier chamber 16 is filled
15 through either the inlet 12 or the outlet 14 with the
16 humidifier 10 oriented in a vertical position. As shown
17 in FIGS. 1 and 2, the chamber 16 should be filled with
18 water up to between a pair of fill lines 42 marked on the
19 cover 18. The chamber 16 is made from a transparent
20 material to allow for easy determination of the proper
21 water level. The humidifier 10 is then placed in a
22 horizontal position, so that the baffles 22 extend
23 vertically.

24 Referring again to FIGS. 3-5, when air enters the

1 deflection and the inertia of the air molecules, the air
2 is distributed along the length of the first chamber 24.
3 Continued airflow from the inlet 12 forces the air toward
4 the first set of baffles 22 and eventually through the
5 openings 32.

6 The deflectors 36 create back-pressure and prevent
7 the air from passing to the second chamber 26 too
8 quickly. The deflectors 36 also direct the air outward
9 from the openings 32 and around the arced baffles 22.
10 This air movement continues through the second chamber 26
11 and third chamber 28 until the air is finally pushed into
12 the fourth chamber 30 and through the outlet 14.

13 As shown in FIG. 5, during the time when the air is
14 with each chamber 24-30, a cooperation between the arced
15 shape of the baffles 22, the position of the openings 32
16 and the deflection of the deflectors 36 causes the
17 airflow to enter in an indirect serpentine fashion and
18 circle a number of times within each chamber 24-30 before
19 it exits through the opening 32. The indirect airflow
20 and circling or eddying 44 causes additional turbulence,
21 resulting in increased airflow velocity and significantly
22 extending the duration of contact between the air and
23 water. All of these effects taken together lead to
24 enhanced evaporation and humidification of the air within

1 enhance the eddy effect.

2 Since the baffles 22 do not extend fully to the base
3 20, the water is free to flow within the chamber 16.
4 This helps to further enhance evaporation and minimize
5 the energy necessary to break water molecules away from
6 the surface of the water by decreasing the effect of
7 surface tension. Thus, as shown in FIG. 6, the direction
8 of air flow tends to cause the water level in each
9 successive chamber 24-30 to be higher than the previous
10 one. For this reason, no deflector 36 is provided at
11 opening 34, helping to prevent excess back-pressure from
12 accumulating and causing water to be forced through the
13 outlet 14.

14 Further, both the inlet 12 and the outlet 14 are
15 raised above the top of the cover 18 to help prevent
16 water from inadvertently flowing out of the chamber 16.

17 In addition to humidifier efficiency, the design of
18 the humidifier 10 is based on some other considerations.
19 The cover 18 is provided with lateral ribs 48 that
20 provide help to stiffen the surface of the cover 18.
21 This, along with the flat top design of the cover 18,
22 allow a CPAP device to be placed on top of the humidifier
23 to minimize the overall footprint. The ribs 48 have been
24 strategically positioned to help trap airflow and to some

1 provide additional strength. This ribbing 50 is designed
2 to mirror the baffles 22 within the chamber 16 for purely
3 aesthetic reasons.

4 As shown in FIGS. 1-2, the cover 18 can be
5 molded from a single piece of rigid plastic and
6 permanently secured to the base 20. As shown in FIG. 7,
7 the cover 18 is secured to the base 20 using a permanent
8 adhesive 52. Since many prior art devices are clamped
9 together and sealed with a flexible gasket, they are more
10 prone to leakage. To further prevent leakage, a tongue
11 54 provided on the cover 18 fits into a groove 56
12 provided on the base 20 and the adhesive 52 fills a void
13 58 between the tongue and the groove. Excess adhesive 52
14 flows into gaps 60 that remain between the cover 18 and
15 the base 20.

16 Alternatively, as shown in FIG. 8, a removable cover
17 18' can be used. The removable cover 18' is formed as
18 two-piece structure. A main cover portion 18a is formed
19 from rigid material, like that of the one-piece cover 18.
20 The main portion 18a is surrounded by a sealing cover
21 portion 18b that is formed from a flexible material, such
22 as rubber, molded around the main portion 18a. The
23 flexible sealing portion 18b forms a sufficiently air and
24 water tight seal with a modified base 20', but is

1 resilient nature of the sealing portion 18b keeps the
2 cover 18' securely in place on the base 20'.

3 Alternatively, the cover 18' could be constructed as a
4 single piece.

5 As shown in FIGS. 9 and 10, the base 20' has a
6 ribbed projection 62 which extends around the top edge of
7 the base 20'. The projection 62 snaps into a
8 corresponding recess 64 on provided in the bottom edge of
9 the sealing portion 18b. A tab 66 is provided on the
10 sealing portion 18b to allow the sealing portion 18b to
11 be deformed by manually applied pressure, breaking the
12 seal and allowing removal of the cover 18'.

13 Further, because CPAP devices generally contain
14 electric motors, they tend to produce heat when run
15 continuously. By placing a CPAP device on top of the
16 humidifier chamber 16, some heat may be transferred to
17 the water, thereby increasing the rate of evaporation.

18 To further enhance humidification, a separate heater
19 (not shown) could be provided to the humidifier 10.
20 Although heaters are well known for use with humidifiers,
21 a heater used with the present design would adequately
22 work at lower temperature than in prior art devices.
23 Lower temperatures generally provide safer operation.

24 It should be evident that this disclosure is by way

1 departing from the fair scope of the teaching contained
2 in this disclosure. The invention is therefore not
3 limited to particular details of this disclosure except
4 to the extent that the following claims are necessarily
5 so limited.